USAWC STRATEGY RESEARCH PROJECT

TIME FOR CENTRALIZED CONTROL OF UNMANNED AERIAL SYSTEMS

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ABSTRACT

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The use of UAVs in peace and conflict is not new; however, when UAVs are used to perform tasks historically accomplished by manned aircraft, they make national headlines. The increased use of UAVs in military operations in Kosovo, Afghanistan, and Iraq since prior to the turn of the century has brought the advantages and disadvantages of these systems to the forefront for military users. With the help of a UAV overhead, troops on the ground can get instantaneous situational awareness of the threats behind nearby hills or buildings.

Despite the significant successes of unmanned systems on the battlefield, several issues exist which must be addressed before UAVs can truly integrate into joint and combined operations. The major issues are airspace congestion, frequency/bandwidth saturation, and limited interoperability of UAV systems. This paper will briefly outline the history of UAVs and the anticipated future growth of these systems in militaries around the world, especially in the United States. The main focus will be on detailing the three identified issues with UAVs, and explain why continuing to address each issue with a disjointed, service-specific approach will limit UAV employment in current and future combat zones.

TIME FOR CENTRALIZED CONTROL OF UNMANNED AERIAL SYSTEMS

The age of the unmanned aerial system (UAS)[1] is now. The United States military has tested and employed numerous unmanned aerial vehicles (UAV) and remotely piloted aircraft (RPA) over the past fifty years with a mixture of both success and failure. However, over the last decade, UAVs and RPAs have proven their worth in multiple operations around the world.[2] Last year, at a joint warfare conference in Arlington, Virginia, the former Commander of United States Central Command Air Forces,[3] General Walter E. Buchanan III, reported that UAVs numbered over 1,000 in the skies over combat forces in the Central Command area of responsibility with missions now expanded from basic intelligence gathering to "more complex tactical battle coordination, forward air control, and search-and-rescue support."[4] These systems are making it easier to spot insurgents and roadside bombs in Iraq, thus saving American lives according to Pentagon officials and experts. With the help of a UAV overhead, troops on the ground can get instantaneous situational awareness of the threats behind nearby hills or buildings. According to Christopher Bolkcom, a defense expert for the Congressional Research Service, "One can argue that the standard equipment for a Marine or infantryman now is the helmet, rifle, boots and UAV."[5]

Although use of UAVs in peace and conflict is not new, when UAVs are used to perform tasks historically accomplished by manned aircraft, they make national headlines. However, the increased use of UAVs in military operations in Kosovo, Afghanistan, and Iraq since prior to the turn of the century has brought the advantages and disadvantages of these systems to the forefront for military users. The two commonly agreed upon main advantages of UAVs over manned aircraft are the elimination of the risk to the pilot's life and the aeronautical capabilities of UAVs which are no longer bound by human limitations, such as persistence. Missions which can be better accomplished by UAVs are broken down into three categories referred to as the "3Ds" -- dirty, dull, or dangerous missions which do not require a pilot in the cockpit.[6] A dull mission would include a 30-hour intercontinental bomber mission originating and returning to a base in the United States. A dirty mission would involve flying into airspace where radioactive fall-out exists. And a dangerous mission could be any number of missions over hostile territory where the enemy forces possess an effective integrated air defense system.[7]

Despite the significant successes of unmanned systems on the battlefield, several issues exist which must be addressed before UAVs can truly integrate into joint and combined operations. The major issues are airspace congestion, frequency/bandwidth saturation, and

limited interoperability of UAV systems. The first two issues are clearly articulated in a *Defense News* interview with General Buchanan:

> Deconflicting the airspace shared by fixed wing aircraft and UAVs, most of which operate below 3,000 feet, is a major challenge, Buchanan said. Beyond physical congestion, there is also spectral congestion to consider as well, as line of sight frequencies become increasingly crowded, particularly in Iraq.[8]

In addition, with the large and growing number of UAVs in military operations, if they lack interoperability, the information collected when performing intelligence, surveillance, and reconnaissance (ISR) missions will not get to the individuals who need it most. After visiting deployed U.S. Marine Corps forces in Iraq in 2005, former Commandant of the Marine Corps, General Michael Hagee stated, "UAVs are really quite important. If you talk to the commanders over [in Iraq], they'd like to have more." However, General Hagee identified several problems with UAVs including too few ground stations to downlink all the information that is available and too many different types of ground stations, each tied to a different unmanned system.[9]

This paper will briefly outline the history of UAVs and the anticipated future growth of these systems in militaries around the world, especially in the United States. The main focus will be on detailing the three identified issues with UAVs and explain why continuing to address each issue with a disjointed, service-specific approach will limit UAV employment in current and future combat zones. This paper will show that without a single authority for UAV systems in military operations, all three issues will prevent the effective employment of these systems and potentially result in friendly casualties. I will recommend the designation of a single authority for unmanned systems consistent with joint doctrine, to develop, integrate, and employ UAVs, as well as develop UAV tactics, techniques, and procedures (TTP) for operations in combat zones.

History of Unmanned Aerial Vehicles

Although unmanned systems were used by the United States as early as the American Civil War and in World War II, these programs were extremely rudimentary. In the Civil War, both Union and Confederate forces launched balloons laden with explosive and attempted to land them in supply or ammunition depots, and explode them. The U.S. program in WW II attempted to use manned aircraft in an unmanned role; however, lack of remote control technology limited the success of this effort. The first extensive program came about during the Vietnam War when technology started to make UAVs more effective. Firebee drones were flown over North Vietnam conducting imagery and signals intelligence missions, leaflet drops, and surface-to-air missile radar detection, location, and identification.[10] The first U.S. Air Force operationally significant UAV was the Lightning Bug which was used for tactical reconnaissance

during the Vietnam War. The Air Force attempted other programs during the 1960s and 1970s, but they “suffered from cost overruns, test failures, and unchecked requirements growth (‘mission creep’).” Coupled with the emergence of reconnaissance satellites with near real-time capabilities, UAVs took a back seat during the Cold War.[11]

In addition to U.S. Air Force efforts with UAVs, the Navy and Marine Corps have been operating the Pioneer UAV system since 1985. The Pioneer is a direct derivative of a UAV system developed in Israel.[12] The Israelis enjoyed great success employing UAVs, including the Bekaa Valley Campaign in Lebanon in 1982 where unmanned systems provided ISR on Syrian air defense systems allowing Israeli manned aircraft and surface-to-surface missiles to destroy them. With a desire to develop its own UAV, the United States began a joint program managed by the Navy and run by the Army which resulted in the development of the RQ-1 Predator. In 1996 following the first Gulf War, the Air Force took operational control of the Predator program. The Predator was employed by the Air Force as an ISR platform and it saw action in every major military operation since its first overseas deployment to the Balkans. The RQ-1 Predator was later armed with the AGM-114 Hellfire missile and redesignated the MQ-1 Predator. The MQ-1 Predator is one of the military’s most requested systems and is used in the Global War on Terrorism to find, fix, track, target, engage, and assess suspected terrorist locations.[13]

With the success of Predator, other Unmanned Aircraft (UA) were developed and employed, and missions were expanded beyond simple reconnaissance to help combat forces execute the Global War on Terrorism.

> As of September 2004, some twenty types of coalition [unmanned aircraft] UA, large and small, have flown over 100,000 total flight hours in support of Operation ENDURING FREEDOM (OEF) and Operation IRAQI FREEDOM (OIF). Their once reconnaissance only role is now shared with strike, force protection, and signals collection, and in doing so, have helped reduce the complexity and time lag in the sensor-to-shooter chain for acting on “actionable intelligence.”[14]

This demand for unmanned aircraft appears to be just the beginning as the Services see these systems as an integral component of their future tactical formations.[15] The Army’s transformation plan outlined in its 2006 Posture Statement envisions UAVs as a significant contribution to the Future Combat System, thereby integrating advanced technology into formations for increased capability and to provide greater protection.[16] The Army is not alone in its investment in unmanned technology for the future.

The Future of Unmanned Aerial Systems

The true acid test for commitment to a system or capability in the Department of Defense (DoD) is the expenditure of dollars (see Figure 1 below). In the 1990s, the DoD spent just over $3 billion on development, acquisition, and operation of UAV systems. However, following the tragic events of September 11, 2001, the DoD starting spending more than $1 billion per year on UAV systems, beginning in 2003 and continuing at increased levels until today. This funding level will result in an increase in UAVs from 250 in 2005 to 675 by 2010, and 1400 by 2015 (not including micro and mini unmanned aircraft). These systems will support more than ISR and strike missions, but will also include such missions as signals intelligence collection, cargo lift, and communications relay.[17]

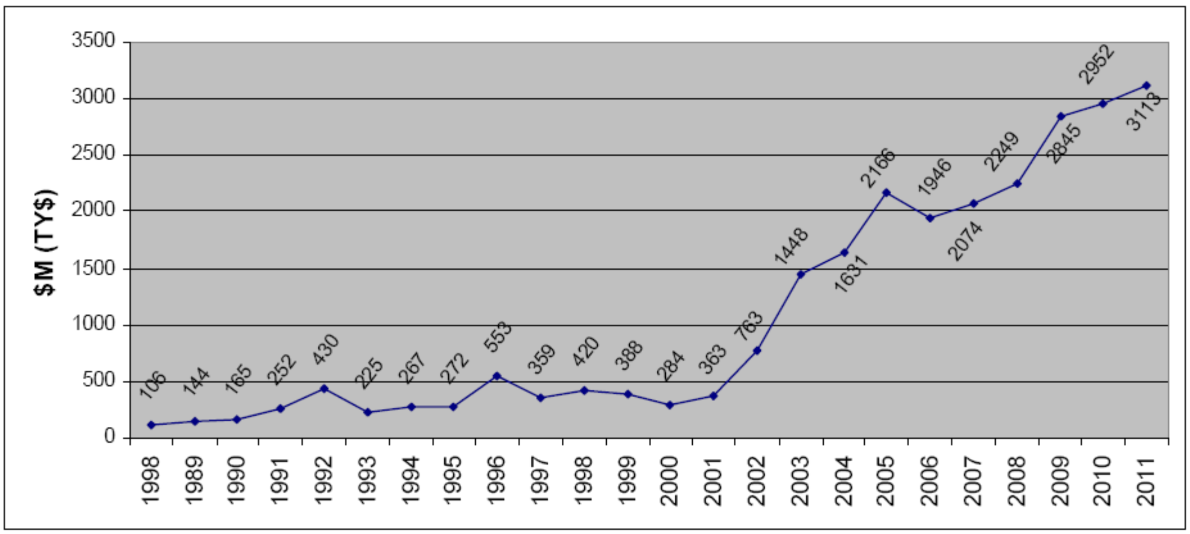

Figure 1. DoD Annual Funding Profile for UAV Systems[18]

This increased emphasis on UAVs is not limited to just the United States. “Currently, some 32 nations are developing or manufacturing more than 250 models of UA…41 countries operate some 80 types of UA, primarily for reconnaissance.”[19] In the area of Unmanned Combat Aerial Vehicles (UCAV), countries such as France, Israel, Italy, and the United Kingdom have initiated programs for target acquisition and engagement missions since 2001.[20] Aside from the obvious concerns of interoperability and deconfliction arising from friendly nations developing and manufacturing unmanned systems for combat, the fear is these systems will find their way into the hands of our enemies. Hizbollah militants have flown UAVs over Israel and Al Qaeda has monitored Pakistani soldiers using UAVs. Given that these systems can be armed, they can become cost effective weapons for non-state actors and sought after as a “poor man’s air force.”[21]

Predictions vary widely on the number of missions UAVs will take away from manned aircraft. The National Defense Authorization Act for Fiscal Year 2001 stated, “Within ten years, one-third of U.S. military operational deep strike aircraft will be unmanned.” However, despite acceleration of UAV production, manned aircraft still remained 95 percent of DoD’s aircraft inventory in 2005 which suggests that UAVs will not likely be replacing manned aircraft in the foreseeable future.[22] Even more optimistic is retired USAF Colonel John Warden (former fighter pilot and architect of the first Gulf War air campaign) who predicts that 90 percent of combat aircraft will be unmanned by 2025.[23] The Teal Group[24] conducted a study in September 2006 which predicts “the world UAV market will exceed $54 billion over the next 10 years. The U.S. Army alone expects to have 10,000 UAVs by 2011, compared with around 1,200 today.”[25] With the current and future increase in UAV systems, regardless of which prediction becomes reality, issues such as airspace and frequency congestion, and limited interoperability must be addressed and ultimately resolved.

<u>Command and Control Issues for Unmanned Aerial Systems</u>

The three major issues associated with introduction and operation of UAVs in the combat environment are associated with the command and control of these systems; congestion in the airspace, frequency/bandwidth saturation, and interoperability shortfalls limiting intelligence data dissemination resulting from multiple numbers and types of UAV systems. The DoD’s *Unmanned Aircraft Systems Roadmap, 2005-2030*, lists the following as three of the nine issues identified from UAV operations in the Global War on Terrorism:

1. The dynamic nature of the joint operational environment for which UAS are employed is Afghanistan and Iraq indicate a need for centralized command and control to ensure functional integration (intel, ops and communications) that prioritizes UA sensing operations support.
2. A comprehensive and integrated dissemination architecture is needed to optimize bandwidth usage and maximize requirements satisfaction.
3. A net-centric approach to UAS integration/interoperability is needed to provide situational awareness at all command echelons. Consistent with the DoD’s New-Centric Data Strategy, there should be additional capability for archiving and discovery of full motion video collected by UAS.[26]

These three issues stem from each Service developing, deploying, and operating their own separate systems in the combat zone without any attempt to integrate with sister services’ operations. To resolve employment and integration issues, each service must work together to

find ways for unmanned systems to benefit the entire combined force and not just individual services or units.

Airspace Congestion and Deconfliction

The issue of centralized command and control will be addressed first as it is the most dangerous to operations in a combat environment. "Airspace is becoming increasingly and dangerously congested over the skies of Iraq and Afghanistan, [General] Buchanan said. The result could decrease the effectiveness of the UAV fleet, or worse, result in the loss of our own soldiers in a tragic midair collision."[27] Today's environment in the battlespace over Iraq is the result of a lack of a unified approach to UAV operations in Iraq. With approximately 750 UAVs operating in the skies over Iraq, there has been at least one midair collision between a small Raven[28] UAV and an OH-58 helicopter. The situation is not any better in Afghanistan where there was a recent near-miss between a German military Luna[29] UAV and an airliner with gear and flaps down on approach to Kabul.[30]

There is agreement among leadership in the services that something needs to be done to resolve the issue of UAV deconfliction and congested airspace. Former Commandant of the Marine Corps, General Michael Hagee, emphasized that "with the services' growing use of UAVs crowding the airspace, the services as well as the Marine Corps, will need to work on deconfliction of airspace."[31] Brigadier General E.J. Sinclair, Commander of the U.S. Army Aviation Center stated, "As we proliferate more UAVs, the deconfliction of manned and unmanned vehicles is a challenge."[32] Overcoming this challenge will involve "rule-based operational procedures and protocols for deconfliction of assets coupled with the technology to realize the concept." In addition to a single, integrated air picture and robust, wideband data links, there will need to be significant advances in precision navigation and global positioning systems for UAVs, especially unmanned aircraft carrying live munitions.[33]

In joint warfare, joint doctrine guides operations involving multiple services. For air operations, Joint Publication (JP) 3-30, *Command and Control of Joint Air Operations*, provides the following for all aircraft supporting the Joint Force Commander's (JFC) operation:

> Component air operations must adhere to the guidance provided by the airspace control plan (ACP), the airspace control order (ACO), the area air defense plan (AADP), and the special instructions (SPINS) located in the air tasking order (ATO) to assure deconfliction, minimize the risk of fratricide, and optimize the joint force capabilities in support of the JFC's objectives.[34]

Further, JP 3-30 states that all air missions are subject to the ACO which "provides direction to deconflict, coordinate, and integrate the use of airspace within the operational area."

There are a wide variety of methods to accomplish this deconfliction, coordination, and integration, ranging from positive control of all air assets to procedural control. It is the JFC's Airspace Control Authority (ACA), normally the Joint Force Air Component Commander (JFACC), who decides the appropriate method based on the JFC's concept of operation. The selected method is communicated to all components through the airspace control plan.[35]

Additional guidance for airspace control is provided specifically for UAVs in JP 3-52, *Joint Doctrine for Airspace Control in the Combat Zone*. It allows for each joint force component to operate UAVs in the combat zone and highlights that "established principles of airspace management used in manned flight operations will normally apply to UAV operations." It recognizes the difficulties of visually acquiring UAVs and states they do not always provide a "clear radar or electronic signature, presenting a potential hazard to other aircraft." The remainder of the short paragraph on UAVs in JP 3-52 discusses the need for special considerations for these systems in terms of airspace control and usage. The two methods suggested fall well short of positive control measures and would be considered procedural control. JP 3-52 states, "Specific volumes of airspace need to be included in the ACO. Additionally, the ACO should provide times of activation of airspace for UAV operations." Therefore, the joint solution for deconfliction in the combat zone involves separating unmanned from manned aircraft in airspace and/or designating specific time periods to conduct UAV operations. JP 3-52 does, however, attempt to encourage integrated operations with its closing line of the paragraph stating, "efforts should be made to integrate UAVs with manned flight operations to enable a more flexible and adaptable airspace structure."[36]

As joint doctrine suggests, deconfliction between manned and unmanned aircraft can be accomplished by separation in time and/or space. However, in the combat environment in Iraq or any future urban warfare situation, the situation is a great deal more complicated. Brigadier General Robert P. Lennox, Commander of the U.S. Army Air Defense Artillery Center, describes this environment in a recent *National Defense* article, "You might have missiles flying, UAVs, communications relay systems, intelligence systems, all in the same airspace, staring at the same area on the ground."[37] Add manned aircraft providing close air support into the equation and the potential for fratricide and/or collateral damage increases significantly. The U.S. Air Force is the most experienced service component for airspace management, but this expertise is typically confined to aircraft systems flying above 10,000 to 15,000 feet. The U.S. Army is attempting to resolve the congestion problem by fielding six-person "airspace management cells" comprised of aviators and air defense specialists, and assigning them to maneuver brigades to provide situational awareness of the battlespace above their unit. These cells would

"synchronize the airspace" to coordinate the traffic of low-altitude aircraft in their particular volume of airspace.[38] This would effectively provide for decentralized control and decentralized execution of the airspace in the combat zone.

Air Force Doctrine Document 1, *Basic Air Force Doctrine*, clearly articulates the importance of centralized control and decentralized execution of air and space forces: "Centralized control and decentralized execution of air and space power are critical to effective employment of air and space power. Indeed, they are the fundamental organizing principles for air and space power, having been proven over decades of experience as the most effective and efficient means of employing air and space power."[39] Joint doctrine states the same principle, though not as forcefully as Air Force doctrine: "Joint air operations are normally conducted using centralized control. Centralized control is placing within one commander the responsibility and authority for planning, directing, and coordinating a military operation or group/category of operations. Through centralized control of joint air operations, the JFACC provides coherence, guidance, and organization to the air effort and maintains the ability to focus the tremendous impact of air capabilities/forces wherever needed across the theater of operations. Additionally, this assures the effective and efficient use of air capabilities/forces in achieving the JFC's objectives."[40]

Despite existing service and joint doctrine, no procedures exist between units operating in current combat zones to actively manage the airspace for all aircraft, manned and unmanned, through centralized control. The Air Force acknowledges the problem in its RPA and UAV Strategic Vision, but offers no specific recommendations. It simply states that larger unmanned vehicles which operate at higher altitudes where conflicts with manned aircraft are more likely, must follow the ACO and be included on the Air Tasking Order. For smaller UAVs, it only states, "Procedural deconfliction may be necessary to allow for the sheer number of smaller UAVs operating at lower altitudes." In addition, it also says that "responsive, agile integration procedures that permit rapid changes within the airspace must be developed as well, permitting RPAs and UAVs to enhance rather than hinder mission performance."[41] For these procedures to be developed, a single organization must be given authority to develop, coordinate, and implement them with all players operating in the joint battlespace.

<u>Frequency Saturation and Bandwidth Allocation</u>

Similarly, the issue of frequency saturation while recognized by all services lacks an identified organization to work the issue. General Buchanan, former Combined Forces Air Component Commander (CFACC) for U.S. Central Command, emphasizes that beyond

physical congestion in combat zone airspace, spectral congestion is also a concern, as line-of-sight frequencies are significantly crowded, especially in Iraq.[42] Frequency management is critical for any modern military force which operates in and relies on the radio-frequency (RF) spectrum. During Operation ALLIED FORCE, 44,000 frequencies were deconflicted by frequency coordinators. “The frequency spectrum is a battleground between competing interests.” As the frequency spectrum is consumed by RF users, the “remaining smaller portions of the spectrum have become more difficult to deconflict.” This competition within limited frequency bands presents serious problems for UAVs carrying ISR payloads. “The considerable amount of bandwidth consumed by UAVs…makes apparent the fact that bandwidth allocation and management are now as operationally important as airspace control and the allocation of tanker, jamming, and defense-suppression assets.”[43]

In an *Air Force Magazine* article following the release of DoD’s *Unmanned Aircraft Systems Roadmap, 2005 to 2030*, Lieutenant General Donald J. Hoffman, military deputy to the Assistant Secretary of the Air Force for Acquisition, cited the frequency spectrum as “one of the most prominent challenges” to widespread use of UAV systems. He further states that within the U.S., the frequency spectrum has been sold off for electronic devices, such as cell phones, satellite communications, and high-definition TV. This will require a new core competency which General Hoffman calls “frequency dominance” to get other users off frequencies required by U.S. forces to operate UAVs in the combat zone.[44] Unmanned systems are dependent upon bandwidth for control of the aircraft itself and for transmission of collected data, thus a need exists for agile frequency spectrum management according to the *U.S. Air Force RPA and UAV Strategic Vision*. “In an environment with highly-mobile RPAs and UAVs, frequency spectrum management must cover a wider range of dynamic capabilities. This spectrum allocation process must allow flexible frequency reassignments between organizations and Services in a joint environment.” The strategic vision further states, “The Air Force must work with DoD and other Government agencies to establish overall bandwidth requirements for unmanned systems and prioritize them relative to all other connectivity demands.”[45]

Given the finite bandwidth which exists for all military aircraft, there may not be enough to go around for further expansion of UAV programs. The requirements for bandwidth grow with each war the United States fights. “The increased use of UAVs in the Iraq war indicates that remotely piloted platforms and their mass consumption of bandwidth will require a more robust information transfer system in the coming years.”[46] To be certain, the demand for bandwidth for new weapon systems like UAVs continues to grow and commanders must increase their awareness of the growing dependency on bandwidth, limitations in the RF spectrum, and data-

throughput capacity. Absent any technological advancements to increase bandwidth in the future, military leaders will need to make significant trade-offs when employing forces for combat operations.[47] This will require some level of centralized control over unmanned systems operating in the battlespace to ensure the best use of bandwidth to achieve the joint force commander's objectives.

Unmanned Aerial System Interoperability

The third major issue associated with UAV systems in the combat zone is the limited interoperability of UAVs with ISR missions to share the collected intelligence with all warfighters in the battlespace. According to the former Commandant of the Marine Corps in discussions on Operation IRAQI FREEDOM, "[The information is] no good unless you are able to pull it down, everyone is able to pull it down, and not have a different ground station for every single device you have up there." General Hagee added that we have a long way to go before resolving this issue.[48] General Buchanan, former CFACC for U.S. Central Command, sees all the issues tied together with the answer being technology to improve UAV capability while reducing the total number required over the battlespace. "The answer is not one UAV per soldier, but delivering the effect of one per soldier," Buchanan said. He went on to envision future systems with a "user-specific data download capability" supporting multiple warfighters. In addition to each UAV supporting multiple users, having more than one sensor per UAV could, according to General Buchanan, "allow for independent target identification for multiple users as well."[49]

To support multiple users from different combat units, or even different services and countries, will require some level of interoperability and common standards for data dissemination. "Integration is one of the major challenges still facing the military in its use of UAVs," said Captain Daniel C. Duquette, head of the U.S. Navy Air Warfare Division's UAV office. He further states that the technology is not the problem, rather it's the interoperability standards which are the bigger challenge. Duquette's main concern is the "last tactical mile, of getting the information to the person in the Humvee, the soldier, the Marine, the allied joint NATO force person who needs to know what's behind the next corner."[50] The U.S. Navy is not the only service looking for interoperability solutions. The U.S. Army and Air Force, both purchasing variations of the Predator UAV[51] to conduct ISR and strike missions, are attempting to resolve their differences over command and control of these platforms. Unfortunately, as of November 2006, they have been unable to come to agreement on whether U.S. Army systems will be under control of field commanders and flown by Army operators in the field or under control of the Combined Air Operations Center and flown by "reachback controllers"[52] in the

United States. They have, however, found a networking solution to ensure ground troops can see imagery from either Services' UAV on field laptops.[53] This is certainly a step in the right direction albeit limited to just one UAV, between just two services. There needs to be much more effort to increase interoperability.

The U.S. Air Force in its RPA and UAV Strategic Vision discusses the issues of interoperability and information sharing, but stops short of making a specific recommendation or establishing a way ahead. The Air Force strategic vision foresees all services migrating to a net-centric environment with the DoD establishing a Distributed Common Ground System (DCGS)[54] to disseminate intelligence products from RPAs and UAVs to units in the field. RPAs and UAVs will feed information into the DCGS "to improve information sharing, enhance the quality of information and situational awareness, enable collaboration and mission agility, and enhance sustainability and speed of command." This vision places significant hopes on the evolving net-centric capabilities of the military to ensure each unit can receive information for all available sources, such as directly from the unmanned system, or from the DCGS.[55]

The *Unmanned Aircraft Systems Roadmap, 2005-2030*, clearly states the deficiencies of UAV systems supporting current combat operations are numerous, including lack of standard communications frequencies and waveforms, lack of standardized sensor products, and lack of standardized meta-data for both sensors and platform information. The roadmap lists the highest priority needs to improve unmanned system capabilities in combat operations as:

1. Improving tasking and collection efficiencies through a common, Joint use, ISR tasking and collection management capability that integrates tactical and theater level requirements and capabilities.
2. Improving UA data dissemination and platform access through the use of common, secure, tactical data-links utilizing less congested spectrum.
3. Improving product access and better situational awareness of the current operational picture through improved distribution and networking capabilities.
4. Improved delivery of critical, time sensitive, actionable data to tactical units through improved mobile, 2-way communications capability and associations CONOPS.
5. Improved cross Service, integrated UA and manned CONOPS that provide improved overall collection capability.[56]

In a 2005 report to Congress on UAV issues, Dyke Weatherington, head of DoD's UAV Planning Task Force stated, "There have been cases where a service's UAV, if it could have gotten data to another service, another component, it may have provided better situational awareness on a specific threat in a specific area…." To combat this issue, the Office of the

Secretary of Defense is advancing interoperability as a critical part of its investment plans.[57] However, the UAV industry does not seem to be moving toward architecture commonality. "Contractors would support any mandated interoperability standards, but they also would expect the Defense Department to enforce compliance strictly across the board."[58] Strong leadership and some type of centralized control over procurement of unmanned systems would provide the enforcement industry needs to bring about interoperability standards for UAV systems.

Recommendations

The rapid and growing proliferation of UAVs in combat operations has brought significant advantages to warfighters engaged in the Global War on Terrorism, from improving ISR to enabling precision strike. However, these improvements are at risk of being undermined by three major issues: airspace congestion, frequency/bandwidth saturation, and limited interoperability. Each of these issues stem from an intense effort by each service to field unmanned systems to support their warfighter requirements as quickly as possible with little concern for coordinating efforts, developing common tactics, or ensuring the ability to share the capability with all members of the coalition team. The only way to ensure all UAV systems being developed, procured, and employed by DoD organizations are used in the most efficient and effective manner is to name one service as the executive agent for unmanned aircraft systems.

The UAS Executive Agent's first task is to develop operational tactics, techniques, and procedures for joint combat operations to ensure the threat of mid-air collision between aircraft, manned or unmanned is minimized. The basis for airspace control is already found in joint doctrine, however, specific TTP must be incorporated to account for the growing number of small UAVs and medium/high altitude UAVs which do not have collision-avoidance systems. The lead organization for introducing these new TTP into a combat zone is the JFACC, who has responsibility for producing the ACO and ACP. This will also provide an effective means to identify and neutralize enemy UAVs who is certain to identify this current vulnerability and attempt to exploit it.

The second task for the UAS Executive Agent will be to develop procedures to deconflict frequencies and allocate bandwidth in combat theaters. This requires close coordination with the Geographic Combatant Commander's Communications Director (J-6) and service components' communication organizations. In addition, the UAS Executive Agent would advocate development of technologies to reduce the bandwidth requirements for UAVs and/or methods to coordinate sharing of limited available bandwidth. This task will be especially

difficult given the equities involved by all military players across functional areas, many of which also possess growing communication bandwidth needs. If bandwidth limits continue to exist, then uses of the bandwidth must be prioritized. The UAS Executive Agent could develop and implement a coherent process for prioritizing UAV system requirements for the Combatant Commands, functional components, and service organizations.

The third UAS Executive Agent task is to identify, publish, and enforce common standards for UAV command and control systems and ISR tasking, processing, exploitation, and dissemination systems. Without common standards, UAV systems will continue to be "stove-piped" which will at best minimize the systems effectiveness, and at worse cause needless casualties for coalition forces. The UAS Executive Agent will need to break through service culture roadblocks and enlighten leaders of the need to make intelligence collected by UAVs available to all units operating in the battlespace, as well as intelligence analysts at higher headquarters both in theater and around the globe. There is also a need to advocate net-centric capabilities and ensure all Services, Combatant Commands, and Combat Support Agencies are allocating funds to plug into the Global Information Grid.

Given its expertise with air and space operations and experience in commanding and controlling joint air operations as the Combatant Commander's JFACC, the U.S. Air Force should be designated as the UAS Executive Agent for the DoD. The U.S. Air Force is best equipped to determine the optimal employment of air power whether manned or unmanned and can determine the best solution to deconflict and integrate airspace to maximize the effectiveness of all airborne platforms. In addition, the Air Force has experience with frequency management, especially for aircraft and is best situated to find solutions to bandwidth limitations. Lastly, the U.S. Air Force has already developed a functional solution to intelligence sharing and common standards with its DCGS and can lead the community in developing solutions for all Services, and for codifying and enforcing interoperability standards for all UAS.

In addition to designating the U.S. Air Force as the UAS Executive Agent, the DoD should form a joint UAS Steering Group to act as the primary adviser to the UAS Executive Agent on matters of interoperability requirements, common standards, and joint TTP. Experts from each Service and the Office of the Secretary of Defense would form the membership of the UAS Steering Group and make recommendations to the UAS Executive Agent based on service and joint warfighter requirements. The focus of the steering group would be on fielding interoperable and integrated systems which would benefit all warfighters conducting combat operations in the joint operating environment.

Conclusion

In March 2005, the Government Accounting Office criticized the DoD for the lack of an "…oversight body to guide UAV development efforts and related investment decisions."[59] The same month, the DoD rejected an Air Force proposal to be named as the executive agent for UAVs and instead decided to give the job to an all-service Joint UAS Center of Excellence at Creech Air Force Base, Nevada. The center would transform the Air Force UAV Center of Excellence which stood up in March 2005 into a joint organization run by an Army general.[60] While certainly a move to make jointness a priority and not ruffle the feathers of other Services, it falls short of giving this huge responsibility to an organization with the power and influence to make the necessary decisions to bring UAV systems under centralized control, such as a Service department. The UAS Center of Excellence will certainly be valuable in making recommendations to the DoD on specific common standards for both air vehicles and their supporting ground infrastructure, such as mid-air collision avoidance technology; frequency deconfliction, bandwidth allocation methodologies, and signal compression technology advancements; and unmanned technology to create an interoperable and integrated UAV family of systems. The UAS Center of Excellence would be an excellent candidate to fulfill the role of the joint UAS Steering Group as recommended above. However, the UAS Center of Excellence will not be able to make hard decisions on specific recommendations to adopt, nor determine priorities for system development and employment. These difficult tasks require the strength of a Service Chief, once given the necessary responsibility and authority. The U.S. Air Force is uniquely suited to accept this responsibility and lead the DoD effort to make UAV systems more interoperable, integrated, and effective.

Endnotes

[1] The terms used to describe unmanned systems that operating in the environment above the earth's surface are varied. In this paper, I will use Unmanned Aerial System (UAS) to denote the entire system, which includes the ground element (control station, launchers, etc.) and the air vehicle itself. I will use the term Unmanned Aerial Vehicle (UAV), which is more commonplace to refer only to the actual vehicle or aircraft. The DoD's *Unmanned Aircraft Systems Roadmap, 2005-2030* uses the term Unmanned Aircraft (UA) vice UAV. ("This roadmap adopts the terminology unmanned aircraft (UA), rather than unmanned aerial vehicle (UAV), when referring to the flying component of an unmanned aircraft system. Unmanned Aircraft Systems (UAS) are the focus of this roadmap. This change in terminology more clearly emphasizes that the aircraft is only one component of the system, and is in line with the Federal Aviation Administration's decision to treat "UAVs" as aircraft for regulatory purposes.") *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision, 2005* clarifies terminology for unmanned systems as follows:

"Remotely piloted aircraft" is synonymous with "remotely operated aircraft" and refers to larger unmanned systems such as the MQ-1 Predator and the RQ-4 Global Hawk that operate in controlled airspace. "Unmanned aerial vehicles" refers to systems such as the Raven and Pointer small unmanned systems that do not operate under positive air traffic control and may not require rated operators. The term "unmanned aircraft system" includes the ground element (control stations, launchers, etc.) in addition to the vehicle itself and is more accurate than "unmanned aerial vehicles"; however, the term "unmanned aerial vehicles" is more commonplace. This document uses "unmanned systems" in the generic sense to refer to RPAs and UAVs collectively.

[2] U.S. Air Force, *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 2005, 1.

[3] United States Central Command Air Forces (USCENTAF) is the US Air Force component of United States Central Command. In its service role, the command is also known as the USAF's Ninth Air Force, stationed on Shaw Air Force Base, South Carolina, and its commander reports directly to the Commander, Air Combat Command (COMACC). Currently, for Operations IRAQI FREEDOM, ENDURING FREEDOM and Joint Task Force Horn of Africa, the USCENTAF Commander also serves as the Combined Forces Air Component Commander (CFACC). The CFACC exercises these responsibilities from the Combined Air Operations Center (CAOC) located on Al Udeid Air Base, Qatar.

[4] Rebecca Rayko, "Airspace Congestion Over the Battlefield Affects UAVs," *Defense News*, October 25-26, 2005, 1; available from http://www.defensenews.com/conferences/jw/index.html; Internet; accessed 12 Nov 2006.

[5] Tom Vanden Brook, "Drones reshaping Iraq's battlefields," *USA Today*, 6 July 2006.

[6] Harlan Geer and Christopher Bolkcom, *Unmanned Aerial Vehicles: Background and Issues for Congress*, CRS Report for Congress, updated November 21, 2005, 1.

[7] U.S. Department of Defense, *Unmanned Aircraft Systems Roadmap, 2005-2030*, (Washington, D.C.: U.S. Department of Defense, 4 August 2005), 2.

[8] Rayko, 1.

[9] Geoff Fein, "Marines Seeing Benefits of UAVs and Network Centric Operations," C4I News, Potomac: August 4, 2005, 1.

[10] Jim Garamone, "From the U.S. Civil War to Afghanistan: A Short History of UAVs", *DefendAmerica*, official U.S. Department of Defense website, April 2002, 1; available from http://www.defendamerica.mil/articles/apr2002/a041702a.html; Internet; accessed 15 Dec 06.

[11] *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 1.

[12] Garamone, 1.

[13] *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 2.

[14] *Unmanned Aircraft Systems Roadmap, 2005-2030*, i.

[15] Ibid, 1.

[16] The Honorable Francis J. Harvey and General Peter J. Schoomaker, *A Statement on the Posture of the United States Army 2006*, Office of the Chief of Staff, U.S. Army, Executive Office of the Headquarters Staff Group, 11; available from http://www.army.mil/aps/06; Internet; accessed 13 Jan 2007.

[17] *Unmanned Aircraft Systems Roadmap, 2005-2030*, 37.

[18] Ibid, 37.

[19] Ibid, 38.

[20] Charles L. Barry and Elihu Zimet, "UCAVs—Technology, Policy, and Operational Challenges," *Defense Horizons*, Center for Technology and National Security Policy, National Defense University, Oct 2001, 3; available from http://www.ndu.edu/inss/DefHor/DH3/DH3.htm; Internet; accessed 12 Nov 2006.

[21] Geer, 37.

[22] Ibid, 6-7.

[23] "Science and Technology: Send in the drones; Unmanned aircraft," *The Economist*, London: November 10, 2001, 107.

[24] Teal Group is an aerospace and defense consulting firm which provides market intelligence to government and industry. The Teal Group's team of analysts covers a diverse range of markets, including aircraft, engines, military electronics, missiles & UAVs, and space. The Teal Group covers these markets from a more general perspective, looking at countries, companies, and US government agencies. The Teal Group website is located at: http://www.tealgroup.com/; Internet; accessed 13 Jan 2007.

[25] Adrian Gerold, "UAV: Manned and Unmanned Aircraft: Can They Coexist?" *Avionics Magazine*, Aviation Today, November 1, 2006; available from http://www.aviationtoday.com/av/categories/military/6115.html; Internet; accessed 6 Jan 2007.

[26] *Unmanned Aircraft Systems Roadmap, 2005-2030*, 68.

[27] Rayko, 1.

[28] RQ-11 Raven is a mini UAV. Weighing in at four and a half pounds with a five-foot wingspan and stretching a mere 38 inches in length, the Raven is by far one of the smallest vehicles in the Army, but its aerial reconnaissance value has quickly earned the respect of battalion commanders in Iraq and has filled a niche at the battalion level when larger UAVs are unavailable. Though not as large or capable as some tactical UAVs, the Raven provides units

with a tremendous live-coverage capability previously available only at higher levels of command.

[29] LUNA is an all-weather, easy to operate unmanned air vehicle (UAV) system for real-time surveillance, reconnaissance and target location at ranges exceeding 65 km with an endurance of more than 3 hours. The LUNA system is in service with the German Army since March 2000 and is successfully performing reconnaissance missions in Kosovo, Macedonia and Afghanistan under severe weather conditions and in difficult terrain.

[30] Charlotte Adams, "UAVs and the Regulatory Gap," *Avionics Magazine*, Aviation Today, 1 August 2005, 2-3; available from http://www.aviationtoday.com/av/categories/military/1037.html; Internet; accessed 12 Nov 2006.

[31] Fein, 1.

[32] Sandra I. Erwin, "Controlling Iraq's Crowded Airspace No Easy Task," *National Defense*, Arlington: December 2005; available from http://www.nationaldefensemagazine.org/issues/2005/Dec1/UF-Controlling.htm; Internet; accessed 15 Dec 2006.

[33] Barry, 9.

[34] U.S. Department of Defense, *Command and Control of Joint Air Operations*, Joint Publication 3-30, (Washington D.C.: Office of the Joint Chiefs of Staff, 5 June 2003), I-3.

[35] Ibid, II-4.

[36] U.S. Department of Defense, *Joint Doctrine for Airspace Control in the Combat Zone*, Joint Publication 3-52, (Washington D.C.: Office of the Joint Chiefs of Staff, 30 August 2004), III-6.

[37] Erwin, "Controlling Iraq's Crowded Airspace No Easy Task."

[38] Ibid.

[39] U.S. Air Force, *Air Force Basic Doctrine*, Air Force Doctrine Document 1, (Washington D.C.: Office of the Chief of Staff of the Air Force, 17 November 2003), 58.

[40] U.S. Department of Defense, *Command and Control of Joint Air Operations*, Joint Publication 3-30, I-3.

[41] *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 14.

[42] Rayko, 1.

[43] Lieutenant Colonel Kurt A. Klausner, "Command and Control of Air and Space Forces Requires Significant Attention to Bandwidth," *Air & Space Power Journal*, Winter 2002, 72-74.

[44] John A. Tirpak, "Will We Have an Unmanned Armada?" *Air Force Magazine*, November 2005, 58.

[45] *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 28.

[46] Geer, 21.

[47] Klausner, 76-77.

[48] Fein, 1.

[49] Rayko, 1.

[50] Margaret Roth, "Services Wrestle With the Challenge of UAV Intelligence Interoperability," *Sea Power*, May 2004; available from http://www.navyleague.org/sea_power/may_04_22.php; Internet; accessed 6 Jan 2007.

[51] The U.S. Army variant of the MQ-1 Predator is called the Warrior. The Army wants the Warrior to run on diesel fuel, rather than aviation fuel like the MQ-1 Predator.

[52] Predator Reachback Operations (also called Remote Split Operations, RSO): The USAF preferred to operate the Predator with "pilot in the loop". During operation in Iraq and Afghanistan, Predators are flown by USAF pilots located in Nellis AFB California. The aircraft and mission payloads are controlled via satellite data link. Sensor feeds are received in the mission control center back in USA via satellite where they are processed and analyzed. The imagery and intelligence products are distributed on the global intelligence network (DCGS, see Endnote below) and are accessible to USAF and other forces worldwide. Raw images can also be used, as they are received directly by units in theater, using video links. The air vehicle is equipped with UHF and VHF radio relay links, a C-band line-of-sight data link which has a range of 150 nautical miles and UHF and Ku-band satellite data links. The UAV Ground Control Station is built into a single 30ft. trailer, containing pilot and payload operator consoles, three Boeing Data Exploitation and Mission Planning Consoles and two synthetic aperture radar workstations On board communications equipment include satellite and line-of-sight) ground data terminals. The Ground Control Station can send imagery data via a landline to the operational users or to the Trojan Spirit data distribution system. The Trojan Spirit II data distribution system is equipped with a 5.5m dish for Ku-band Ground Data Terminal and a 2.4m dish for data dissemination. Source: *Defense Update,* International Online Defense Magazine; available from http://www.defense-update.com/products/p/predator.htm#cont; Internet; accessed 14 Jan 2007.

[53] John A. Tirpak, "UAVs With Bite" *Air Force Magazine*, January 2007, 50.

[54] As the Department of Defense transforms, so does the intelligence enterprise. Forces deployed throughout the world, operating in joint environments, require real-time access to actionable intelligence. The Department of Defense's response to this need is a global, internet-like network where both military and national agencies have access to time sensitive intelligence, surveillance and reconnaissance (ISR) data. This collaborative enterprise is the **Distributed Common Ground System (DCGS)**. The Pentagon states the goal of DCGS as "all DoD sensors and ground stations on a common network creating a shared information environment." As an integrated component of the DoD information grid, DCGS will integrate multiple ISR sensors and systems across the battlefield and draw intelligence data from various sources, then correlate that data into an integrated picture of the battlespace. An open systems

architecture and a revolutionary horizontal integration approach enables interoperability with a wide range of previously “stove-piped” ISR systems. Each service is developing a portion of the DCGS family of systems, the Air Force is already planning the next major upgrade of this net-centric capability that utilizes the DCGS Integration Backbone (DIB). Source: Lockheed Martin; available from http://www.lockheedmartin.com/wms/findPage.do?dsp=fec&ci=17572&rsbci=5&fti=0&ti=0&sc=400; Internet; accessed 14 Jan 2007.

[55] *The U.S. Air Force Remotely Piloted Aircraft and Unmanned Aerial Vehicle Strategic Vision*, 23.

[56] *Unmanned Aircraft Systems Roadmap, 2005-2030*, 45.

[57] Geer, 20.

[58] Sandra I. Erwin, “UAV Programs Need Common Standards, Says Industry Study,” *National Defense*, Arlington: October 2003; available from http://www.nationaldefensemagazine.org/issues/2003/Oct/UAV_Programs.htm.

[59] Geer, 12.

[60] Adam J. Hebert, “Smashing the UAV Stovepipe” *Air Force Magazine*, February 2006, 50.